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(54) Mortar and Concrete Workable in a Wet Spraying Process, and Procedure for Use Thereof

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ABSTRACT OF THE DISCLOSURE

Disclosed are concrete and mortar compositions for wet spraying, that have prolonged setting times (retarded long enough to be delivered from a ready mix plant to a construction site and remaining workable for up to 2 days thereafter), but which can be brought to immediate stiffening, setting and quick hardening by the addition of certain setting accelerators, particularly those based on potassium aluminate.

WHAT IS CLAIMED IS:

1. A setting-retarded mortar or concrete composition, workable in a wet spraying procedure, comprising a hydraulic binder, and modified with a setting-retarding agent to prolong workability time, but said composition being rapidly hardenable upon the addition of 0.5 to 10% based on the weight of the binder of an alkali aluminate-containing setting accelerator, said setting-retarding agent comprising 0.2 to 5% based on the weight of the binder of a liquifier having a retarding effect, or 0.01 to 5.0% based on the weight of the binder of a setting-retarder, or mixtures thereof, wherein the setting retarders and liquifiers having a retarding effect for said setting-retarding agent are selected from the group of inorganic phosphoric acids and salts thereof, organic phosphoric acids and salts thereof, poly-hydroxy compounds, hydroxy-carboxylic acids, lignin-, melamine-, naphthalene-, vinyl- and acryl-based water-reducers (WR), and lignin-, melamine-, naphthalene-, vinyl- and acryl-based high-range water-reducers (HRWR), and mixtures thereof, with the proviso that if a melamine- or naphthalene-based water-reducer or high-range water-reducer is present an additional member of the group must be present.

2. A mortar or concrete composition according to Claim 1, wherein the setting-retarder contains a condensed phosphate.

3. A mortar or concrete composition according to Claim 2, wherein said setting-retarding agent comprises a condensed phosphate selected from pyrophosphate, polyphosphate, hexametaphosphate or phosphonic acid derivatives.

4. A mortar or concrete composition according to Claim 1, wherein the setting-retarding agent comprises a setting retarder contains at least one of salts of hydroxycarboxylic acid and polyhydroxycarboxylic acid such as α-hydroxyacetic acid, citric acid, gluconic acid or heptonic acid.

5. A mortar or concrete composition according to Claim 4, wherein said salts of hydroxycarboxylic acid and polyhydroxycarboxylic acid are α-hydroxyacetic acid, citric acid, gluconic acid and heptonic acid.

6. A mortar or concrete composition according to Claim 1, wherein the setting-retarding agent comprises at least one of a partially hydrolyzed starch and carbohydrate.

7. A concrete or mortar composition according to Claim 1, said setting-retarding agent comprising a lignin-sulfonic acid-, sulfonated melamine-formaldehyde condensate-, naphthalene-sulfonic acid-formaldehyde condensate-, sulfonated vinyl-copolymer- or acryl-copolymer-containing water reducer or high range water reducer.

8. A concrete or mortar composition according to Claim 1, further comprising a thixotropic agent.

9. A concrete or mortar composition according to Claim 8, wherein said thixotropic agent is a swellable cellulose ether, alginates, polysaccharides, or mixtures thereof.

10. A concrete or mortar composition according to claim 1 mixed with about 0.5 to 10% based on the weight of the binder of an alkali aluminate-containing setting accelerator.

11. A mortar or concrete composition according to Claim 10, wherein the setting accelerator further comprises at least one of an alkali carbonate and an alkali hydroxide.

12. A concrete or mortar composition according to Claim 11, where in the setting accelerator the aluminum content is about 5-15%, the carbonate content is about 0-15% and the hydroxide content is about 0.2-10%.

13. A concrete or mortar composition according to Claim 10, wherein the setting accelerator comprises potassium aluminate.

14. A concrete or motor composition according to Claim 13, wherein the setting accelerator further comprises at least one of potassium carbonate and potassium hydroxide.

15. A process for working a mortar or concrete composition according to Claim 1 which is pumpable, in a wet spraying procedure, said process comprising (i) at the place of use adding an alkali aluminate-containing setting accelerator to the pumpable mortar or concrete composition, and (ii) spraying the resulting mixture.

16. A process according to Claim 15, wherein the added setting accelerator further comprises at least one of an alkaline metal carbonate and an alkaline metal hydroxide.

17. A process according to Claim 15, wherein the setting accelerator comprises potassium aluminate.

18. A process according to Claim 16, wherein the alkaline metal carbonate and alkaline metal hydroxide are potassium carbonate and potassium hydroxide.

19. A process according to Claim 15, wherein the setting accelerator is added at the spray nozzle to the pumpable concrete or mortar mixture .

MORTAR AND CONCRETE WORKABLE IN A WET SPRAYING PROCESS, AND PROCEDURE FOR USE THEREOF

BACKGROUND OF THE INVENTION

The invention relates to mortars and concretes compatible with wet spraying, which have prolonged setting times (e.g., retarded long enough to be delivered from a ready mix plant to a construction site, and workable for up to two days thereafter), but which can be immediately brought to stiffening, setting and rapid hardening by adding a setting accelerator thereto, and procedures for using such mortars and concretes in wet spraying techniques.

Developments in sprayable concreting and mechanical concreting are increasingly moving towards wet spraying techniques with their potential advantages of high spraying capacity, high and constant product quality, minimal rebound and low dust formation.

Wet spraying of mortars and concretes, however, has thus far only been used at large construction sites because it was only economical for large-scale spraying projects with large concrete and mortar volumes.

Wet-sprayed concrete or mortar is workable only in a soft plastic consistency. With known mortar and concrete compositions, the mortar or concrete stiffens quickly during interruptions; in such a way that it is necessary to frequently clean the pumping and spraying machines after long interruptions. Cleaning wet spraying machines has proved to be a decisive disadvantage of wet spraying (compared to cleaning dry spraying machines). For example, wet spraying machines are cleaned with large amounts of water by rinsing

all parts thereof, while dry spraying machines and hoses can be cleaned by simply blowing available pressurized air through them. Furthermore, the contents of entire truck mixers have required spraying, which lead to unnecessary and uneconomical additional spray layers under certain circumstances. Particularly with city construction which is often necessarily carried out around the clock, it is also desirable to minimize unnecessary activity (e.g., nocturnal distrubance caused by construction traffic noise must be minimized).

With wet spraying, the mortar or concrete must be of a consistency which is suitable for pumping. In order that suitable consistency, as well as optimal acceleration, could be obtained in conventional techniques, the concrete or mortar was mixed with water-reducers or high-range water-reducers (liquifiers) shortly before working (e.g., at the construction site); this to provide a pumpable consistency. If the water-reducer or high-range water-reducer was pre-mixed into the concrete (e.g., at a ready mix plant), the concrete would prematurely stiffen during transport.

On the other hand, since homogenous mixing of water-reducers or high-range water-reducers is very important to achieve appropriate characteristics for the mortar or concrete, it was undesirable to mix them on-site. Truck mixers are not well suited for optimal mixing of small additions of water-reducers.

Dry spraying procedures also have limitations, particularly in terms of the workability of the dry mixture. For example, dry mixtures where the moisture in the sand and

gravel mixture is below 4%, can only be preserved for at most about 4 hours.

SUMMARY OF THE INVENTION

Accordingly, it is one object of the invention to provide a composition where the consistency of the concrete or mortar can remain constant over several hours, but which can be accelerated to immediate stiffening, setting and quick hardening with a setting accelerator. More particularly, it is an object to provide a concrete or mortar suitable for wet spraying where a water-reducer or high-range water-reducer can be added at a ready mix plant; where the consistency of the concrete or mortar will not change substantially over a period of up to two days and will remain pumpable; where the concrete or mortar is sprayable with a setting accelerator under necessary setting conditions; where after long interruptions the spraying machine does not have to be cleaned; and where there is no substantial decrease in early and ultimate strength in spite of setting-retardation.

These objects and others can be obtained by the present invention which is directed generally to a setting-retarded mortar or concrete composition, workable in a wet spraying procedure, comprising a hydraulic binder, and modified with a setting-retarding agent to prolong workability time, but which is rapidly hardenable upon the addition of 0.5 to 10% based on the weight of the binder of an alkali aluminate-containing setting accelerator. The setting-retarding agent comprises 0.2 to 5% based on the weight of the binder of a liquifier

having a retarding effect, or 0.01 to 5.0% based on the weight of the binder of a setting-retarder, or mixtures thereof, wherein the setting retarders and liquifiers having a retarding effect for said setting-retarding agent are selected from the group of inorganic phosphoric acids and salts thereof, organic phosphoric acids and salts thereof, poly-hydroxy compounds, hydroxy-carboxylic acids, lignin-, melamine-, naphthalene-, vinyl- and acryl-based water-reducers (WR), and lignin-, melamine-, naphthalene-, vinyl- and acryl-based high-range water-reducers (HRWR), and mixtures thereof, with the proviso that if a melamine- or naphthalene-based water-reducer or high-range water-reducer is present an additional member of the group must be present.

By the present invention, all components of the concrete or mortar, with the exception of the setting accelerator, can be mixed in the ready mix plant. The invention offers the advantage of a well homogenized mixture which also has a favorable effect on final strength. Furthermore, the new composition offers the advantage that more uniform concrete mixes (less different) can be produced at ready mix plants since a concrete or mortar can be retarded for long periods of time, and subsequently accelerated for setting at any time.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

As noted above, the invention is directed generally to a setting-retarded mortar or concrete composition, workable in a wet spraying procedure, comprising a hydraulic binder, and modified with a setting-retarding agent to prolong workability

time, which is rapidly hardenable upon the addition of 0.5 to 10% based on the weight of the binder of an alkali aluminate-containing setting accelerator. The setting-retarding agent comprises 0.2 to 5% based on the weight of the binder of a liquifier having a retarding effect, or 0.01 to 5.0% based on the weight of the binder of a setting-retarder, or mixtures thereof, wherein the setting retarders and liquifiers having a retarding effect for said setting-retarding agent are selected from the group of inorganic phosphoric acids and salts thereof, organic phosphoric acids and salts thereof, poly-hydroxy compounds, hydroxy-carboxylic acids, lignin-, melamine-, naphthalene-, vinyl- and acryl-based water-reducers (WR), and lignin-, melamine-, naphthalene-, vinyl- and acryl-based high-range water-reducers (HRWR), and mixtures thereof, with the proviso that if a melamine- or naphthalene-based water-reducer or high-range water-reducer is present an additional member of the group must be present.

Useful water reducers and high range water reducers are those which can provide a setting-retarding effect in addition to their water reducing effect (not all have retarding capabilities). The setting retarders have substantially no liquefying effect.

It is preferred that the setting-retarder contain a condensed phosphate, more preferably one selected from pyrophosphate, polyphosphate, hexametaphosphate or phosphonic acid derivatives.

It is also preferred that the setting retarder contain at least one of salts of hydroxycarboxylic acid and

polyhydroxycarboxylic acid such as α-hydroxyacetic acid, citric acid, gluconic acid or heptonic acid. More preferably, the salts of hydroxycarboxylic acid and polyhydroxycarboxylic acid are α-hydroxyacetic acid, citric acid, gluconic acid and heptonic acid.

The setting retarder can also contain at least one of a partially hydrolyzed starch and carbohydrate.

In another embodiment the setting retarder contains a lignin-sulfonic acid-, sulfonated melamine-formaldehyde condensate-, naphthalene-sulfonic acid-formaldehyde condensate-, sulfonated vinyl-copolymer- or acryl-copolymer-containing water reducer or high range water reducer.

The concrete or mortar composition of the invention can also include thixotropic agents. Preferred thixotropic agents include swellable cellulose ethers, alginates, polysaccharides, or mixtures thereof.

According to the invention, the concrete or mortar composition can be mixed with about 0.5 to 10% based on the weight of the binder of an alkali aluminate-containing setting accelerator.

It is preferred that the setting accelerator also include at least one of an alkali carbonate and an alkali hydroxide. It is even more preferred that in the setting accelerator the aluminum content be about 5-15%, the carbonate content be about 0-15% and the hydroxide content be about 0.2-10%.

In another preferred embodiment the setting accelerator includes potassium aluminate. And, such a setting accelerator

can further include at least one of potassium carbonate and potassium hydroxide.

The invention is also directed to a process for working the aforementioned mortar and concrete compositions in the wet spraying procedure. This process comprises (i) at the place of use adding an alkali aluminate-containing setting accelerator to a pumpable mortar or concrete composition, workable in a wet spraying procedure according to the invention, in an amount of about 0.5 to 10% based on the weight of the binder, and (ii) spraying the resulting mixture.

It is preferred that the added setting accelerator further include at least one of an alkaline metal carbonate and an alkaline metal hydroxide. It is more preferred that the setting accelerator include potassium aluminate; and the alkaline metal carbonate and alkaline metal hydroxide be potassium carbonate and potassium hydroxide.

In a particularly preferred embodiment, the setting accelerator is added to the pumpable concrete or mortar mixture according to the invention at the spray nozzle of a spray machine and the mixture contains the setting retarder in an amount of about 0.01 to 5% by weight of the binder, and/or optionally, a water-reducer or a high-range water-reducer in an amount of about 0.2 - 5% by weight of the binder.

Quite surprisingly and contrary to all theories and practical experience, it was found that a concrete or mortar composition which is retarded for a long period under construction site conditions can actually be brought to immediate stiffening, setting and quick hardening at any time

by the addition of certain highly reactive setting accelerators, preferably accelerators based on potassium aluminate with an aluminum content preferably at 5-15%, carbonate content at 0-15% and hydroxide content at 0.2-10%. In addition, there was little difference in strength development between concretes and mortars of the invention and concretes and mortars in which setting had not been retarded. Even more surprisingly, it was discovered that concretes and mortars that have been retarded in their setting according to the invention, react more intensively and need smaller amounts of setting accelerators to achieve setting accelerations comparable to non-retarded concretes and mortars.

The concretes and mortars according to the invention provide numerous ecological and economical advantages. In addition, the invention provides new areas of application for wet spraying such as multi-phase propulsion in tunnel construction; rolling and sliding form construction; stabilization of constructions, ditches and rocks; form-free constructions; and concrete restoration

The invention is explained below in greater detail by way of certain examples. The examples, however, should not be construed as limiting the invention in any way.

Example 1

This example demonstrates the current state of the art of wet spraying as used at numerous major tunnel construction sites.

The following concrete mix was used at the Heilsberg Tunnel:

concrete volume:	6 m^3
portland cement content:	350 kg/m^3
aggregate:	0 - 8 mm
water: cement ratio	(W/C) = 0.59
flow table spread:	36 - 40 cm

Transportation time from the ready mix plant to the construction site was 25 minutes.

A high-range water-reducer based on a modified melamine and naphthalene sulfonic acid condensate having a slight retardation effect (SIKAMENT 300 - 30) was admixed on-site in an amount of 1%. The flow table spread after 5 minutes of mixing was 46 - 52 cm. The spraying capacity was 6 - 12 m^3/h. Forty minutes after the addition of the high-range water-reducer, a limit on pumping ability was reached. The sprayable period ranged from 30 - 60 minutes. When the spraying time exceeded 40 minutes, the consistency was adjusted by redosing with the high-range water-reducer.

In this application, 5.2% of a setting accelerator based on potassium aluminate, potassium carbonate and potassium hydroxide, was used.

Compressive strengths were 0.3 MPa after 1 hour, and 30 MPa after 28 days.

Example 2

This example demonstrates the present invention.

Concrete mix

Portland cement: 425 kg/m^3
Aggregate: 0 - 8 mm
High-range water-reducer based on sulfonated melamine-formaldehyde condensate: (Sikament 300) 0.8%
Setting retarder of a polyphosphate and poly-hydroxycarbonic acid base: (Sika retarder) 0.6%
Setting accelerator based on potassium aluminate, potassium carbonate and potassium hydroxide: (Sigunit L20) 4%

The concrete supplied from the ready-mix plant had a consistency which was workable and pumpable for at least eight hours. Using 4% of the setting accelerator, excellent stiffening, setting and hardening of the concrete could be achieved at any time. The compressive strengths were 0.4 MPa after 1 hour, and 36 MPa after 28 days.

Example 3

This example further demonstrates the present invention.

Concrete mix

Portland cement: 425 kg/m^3
Aggregate: 0 - 8 mm
Sulfonated vinyl-copolymer based high-range water-reducer with high retarding effect on setting: (Sikament 10) 1.6%
Setting accelerator based on potassium aluminate, potassium carbonate and potassium hydroxide: (Sigunit L20) 4%

The concrete had a good pumping consistency for at least 20 hours. The compressive strengths were 0.3 MPa after 1 hour, and 35 MPa after 28 days.

The setting accelerator was added on-site to the spray nozzle via a dispensing pump.